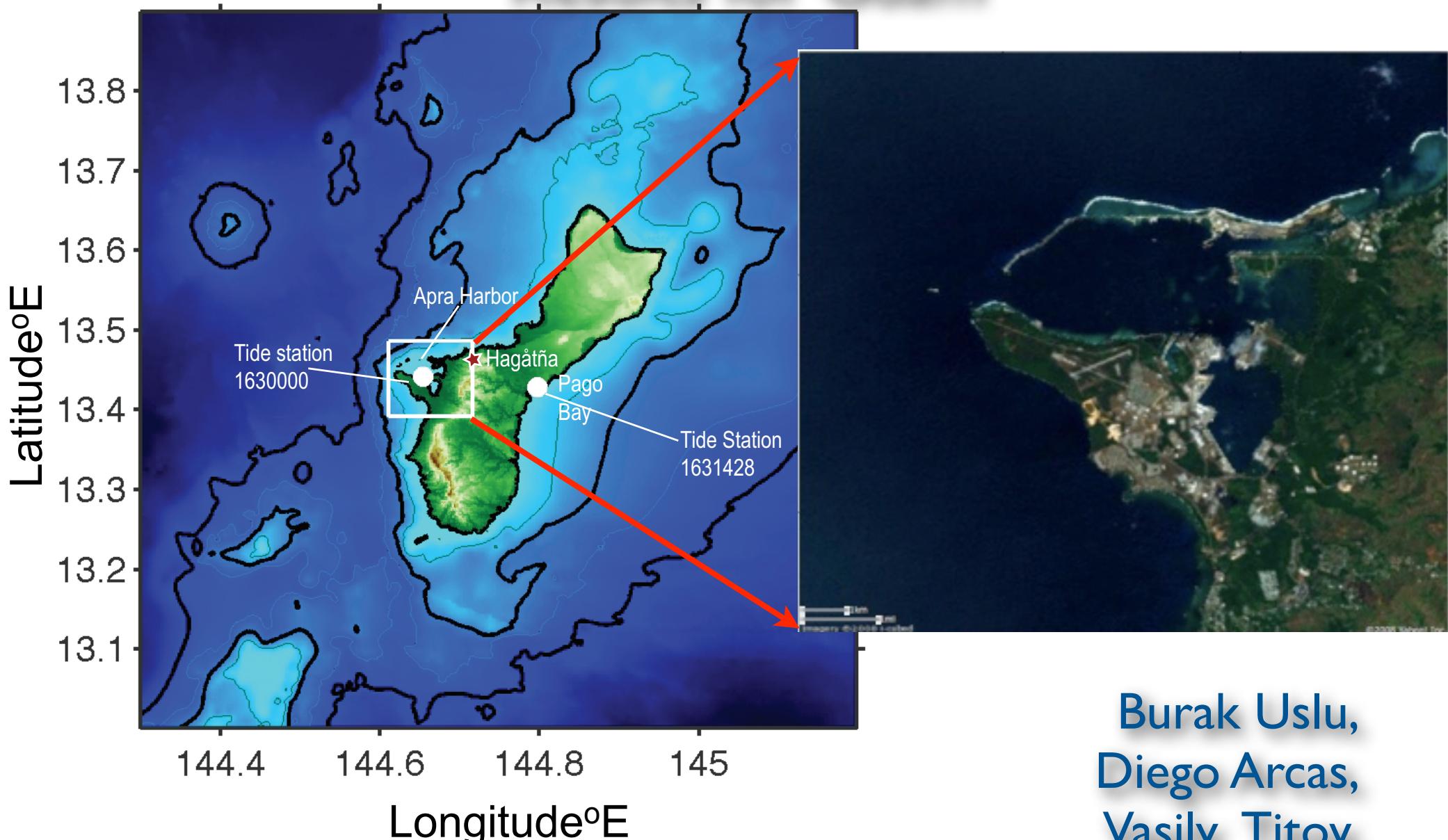


Tsunami Hazard Study of Western Pacific: Results for Guam

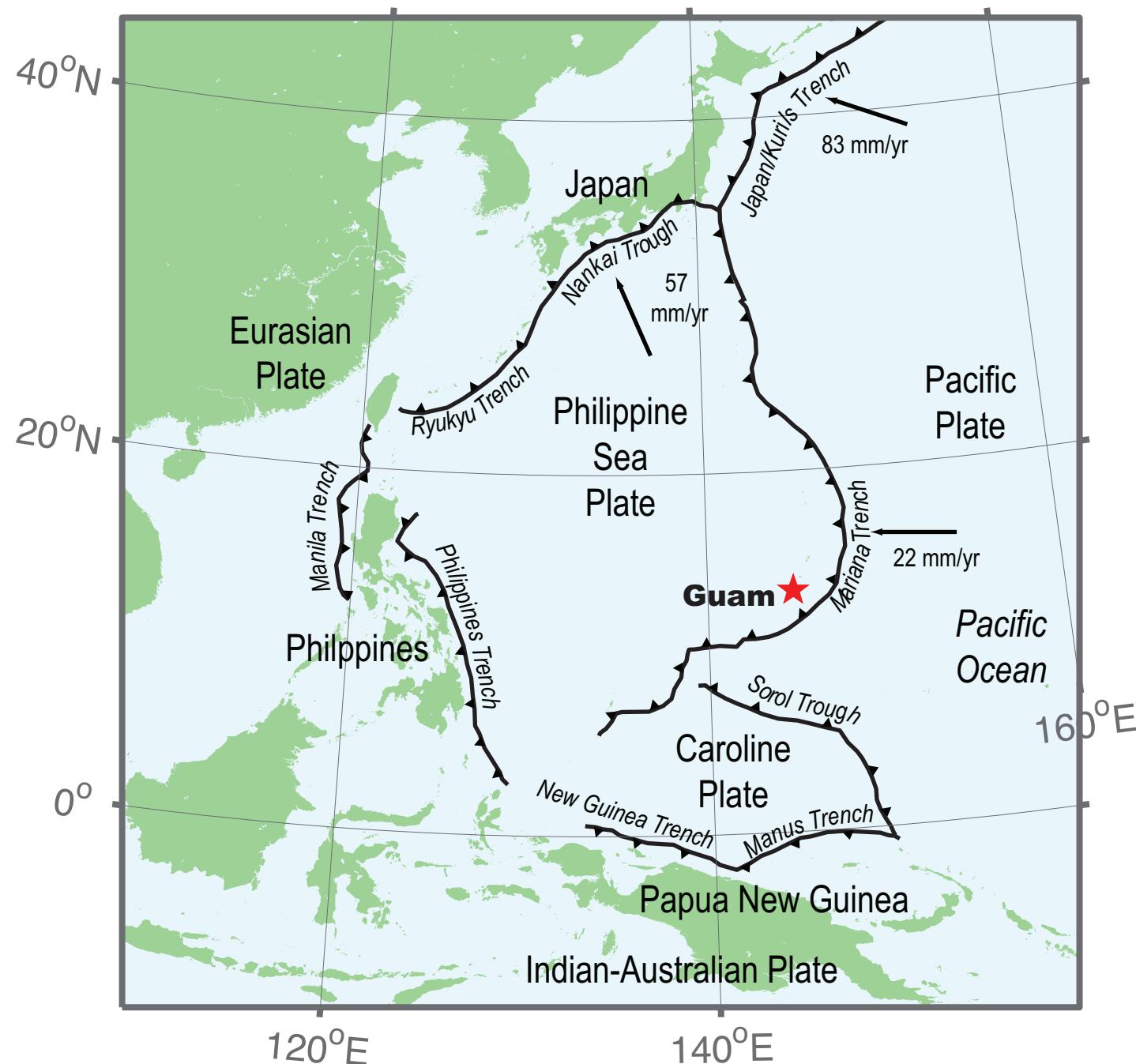


Burak Uslu,
Diego Arcas,
Vasily Titov,
and Chris Chamberlin

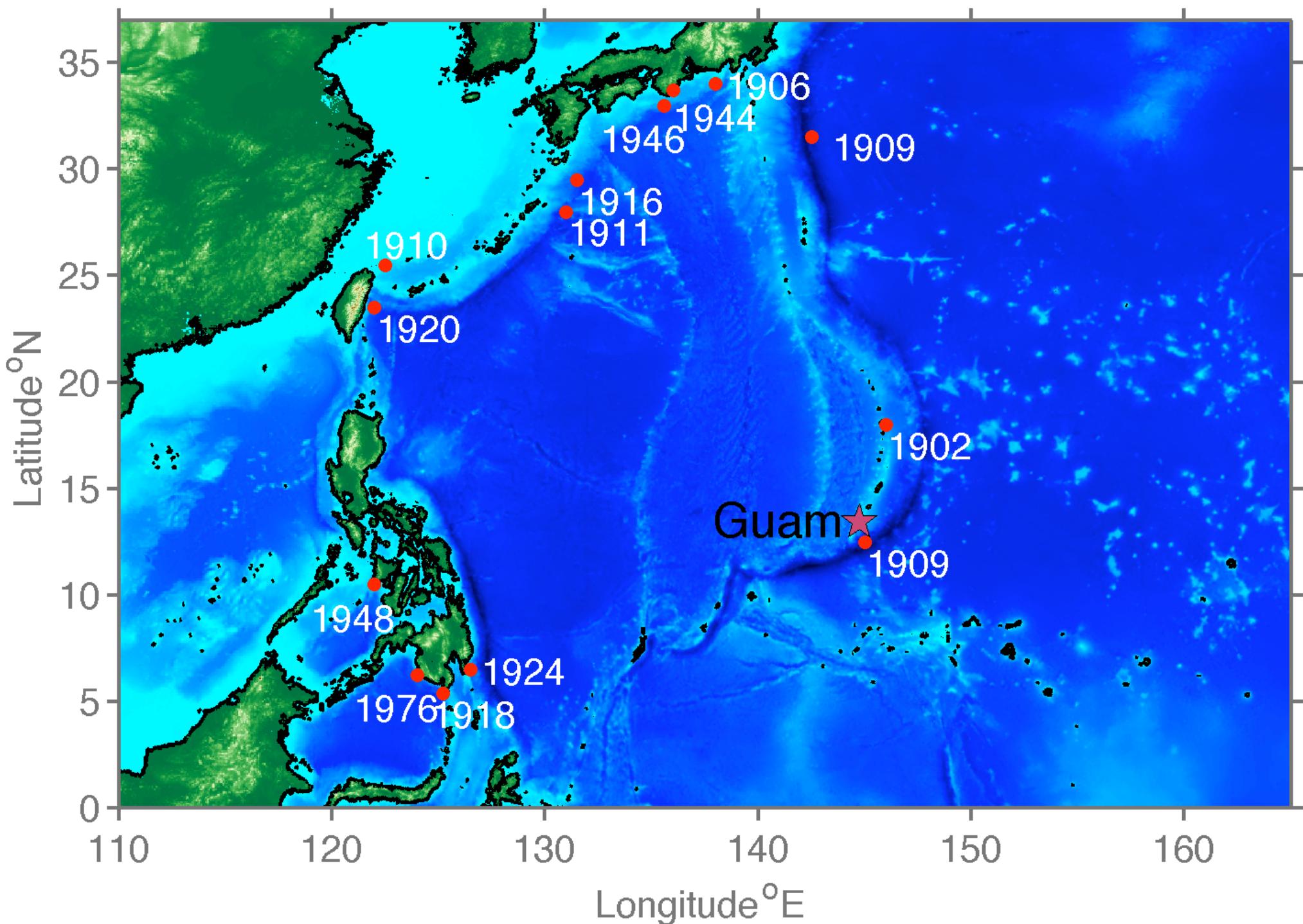
Project Overview

- PRIMO meeting, 2005,
- PRIMO partnership Established 2006,
- Modeling started in summer 2007,
- Final products, spring 2009

Regional settings of the Mariana Trench and surrounding plates (Stein and Okal, 2007; Hall, 2002, 1997)



Tsunamigenic Earthquakes in Western Pacific



Tsunami History in Guam

1837	Unusual activity in the Ocean, two of the Caroline Islands in the South was washed over.
1849	A major earthquake damage followed by a tsunami. Only tsunami fatality in Guam's history.
1892	Water withdraw in Agana Harbor, after the earthquake.
1990	A local quake followed by a tsunami. Confirmed by eyewitness, but no measurements have been made at the time.
1993	A tsunami recorded, but the event was overlooked because of the quake and the Typhoon Steve.

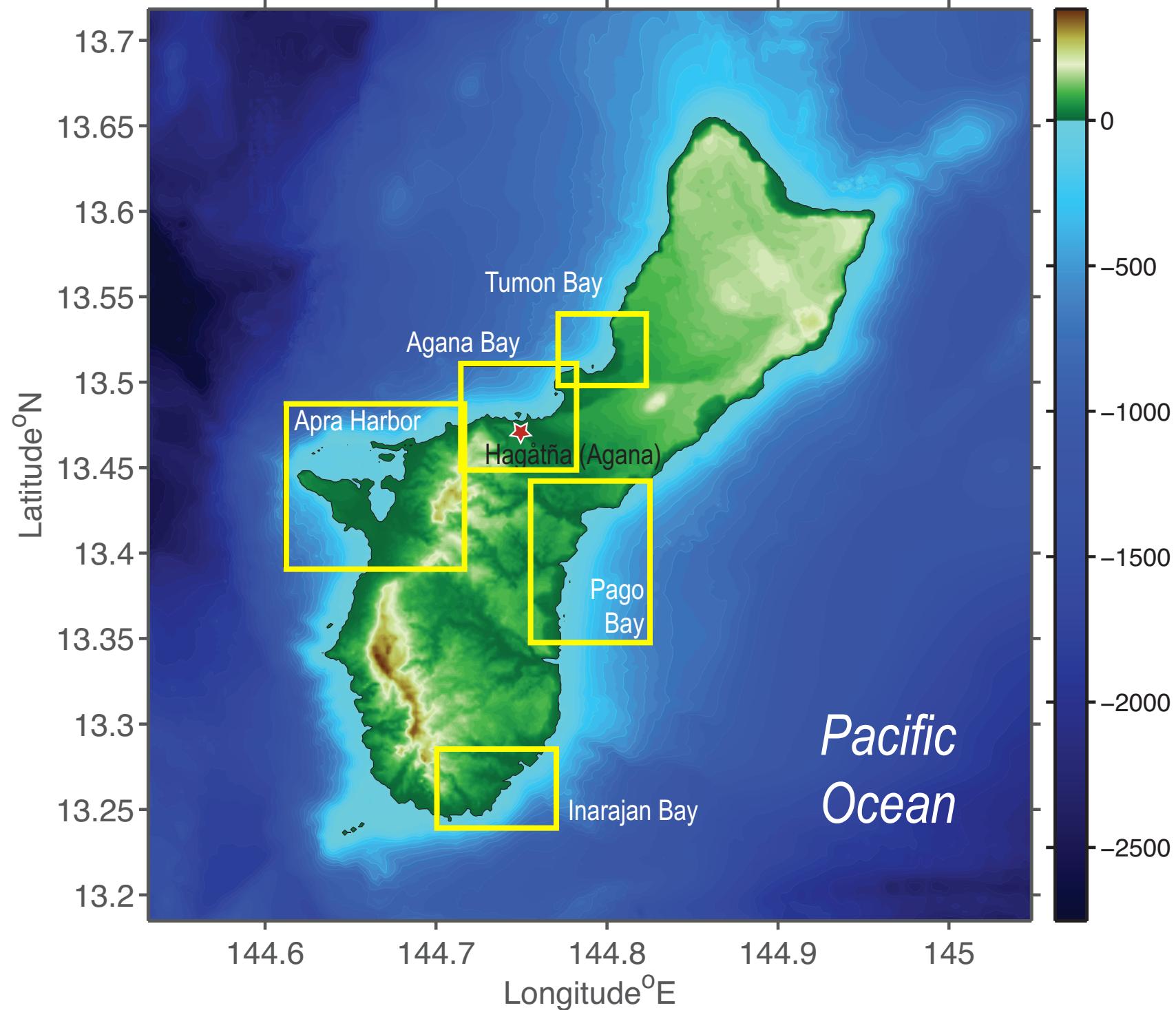
The 3 Large Historical Earthquakes at Apra Harbor

date	source	L(km)	W(km)	disp(m)	Mw	effect
4/10/1952	Kamchatka	800	100	13	9.0	10 cm at Apra Harbor tide gauge
22/5/1960	Chile	1000	100	20	9.2	20 cm wave at the tide guage
28/3/1964	Alaska	400	290/175	10	9.2	5 cm wave at the tide gauge

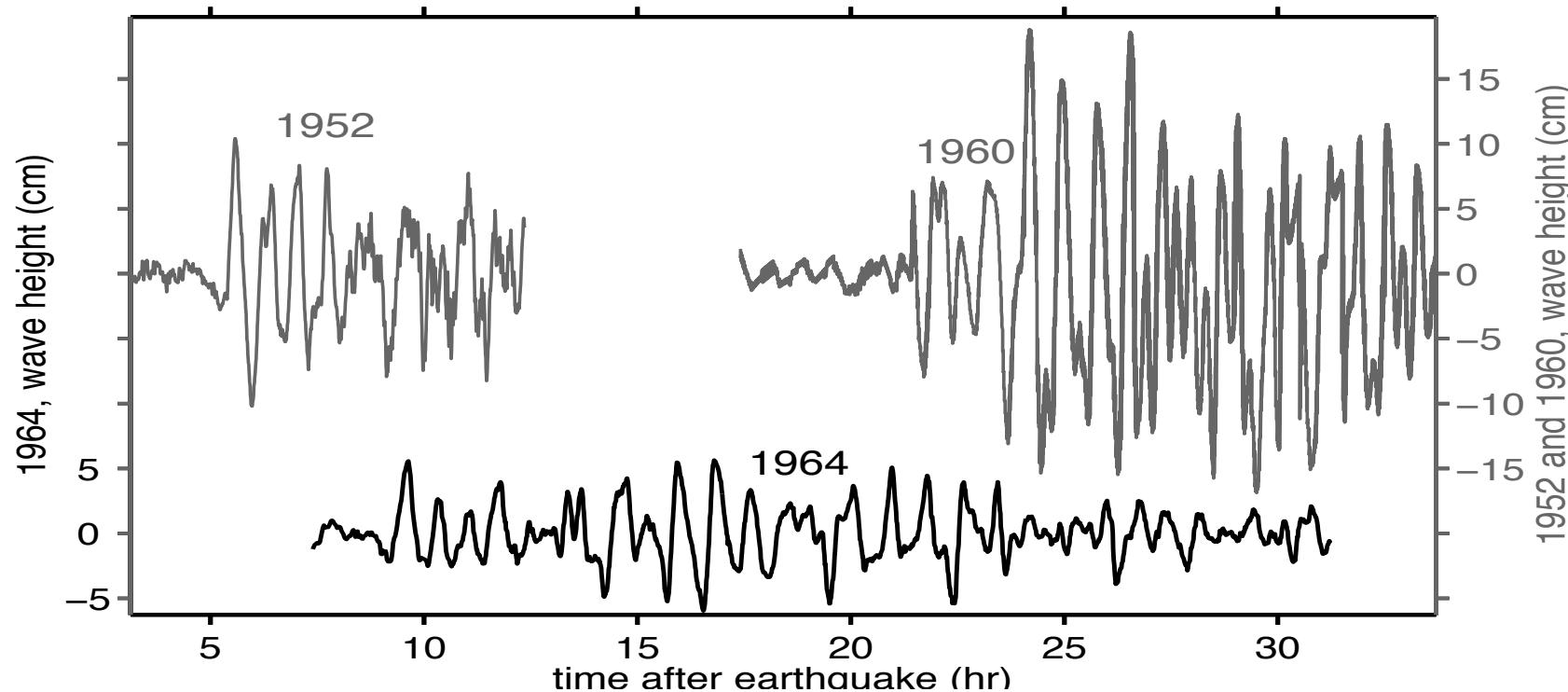
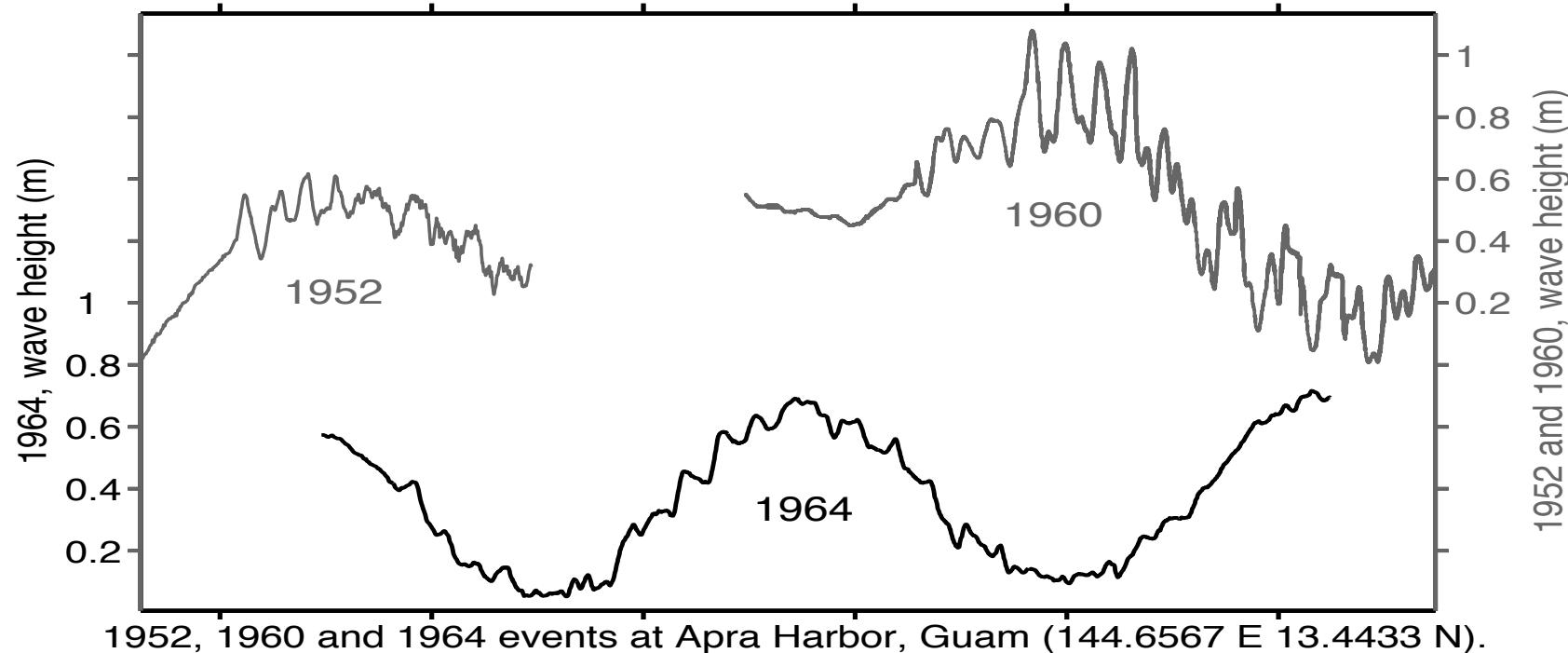
Methodology

- Create high resolution grids.
- Calibrate models with the historical data.
- Develop computationally inexpensive version of the higher resolution grids.
- Model 1128 scenarios with various magnitudes.
- Compute maximum runup heights, inundation distances, numerical tide gauge results for the most dangerous scenarios.
- Report.

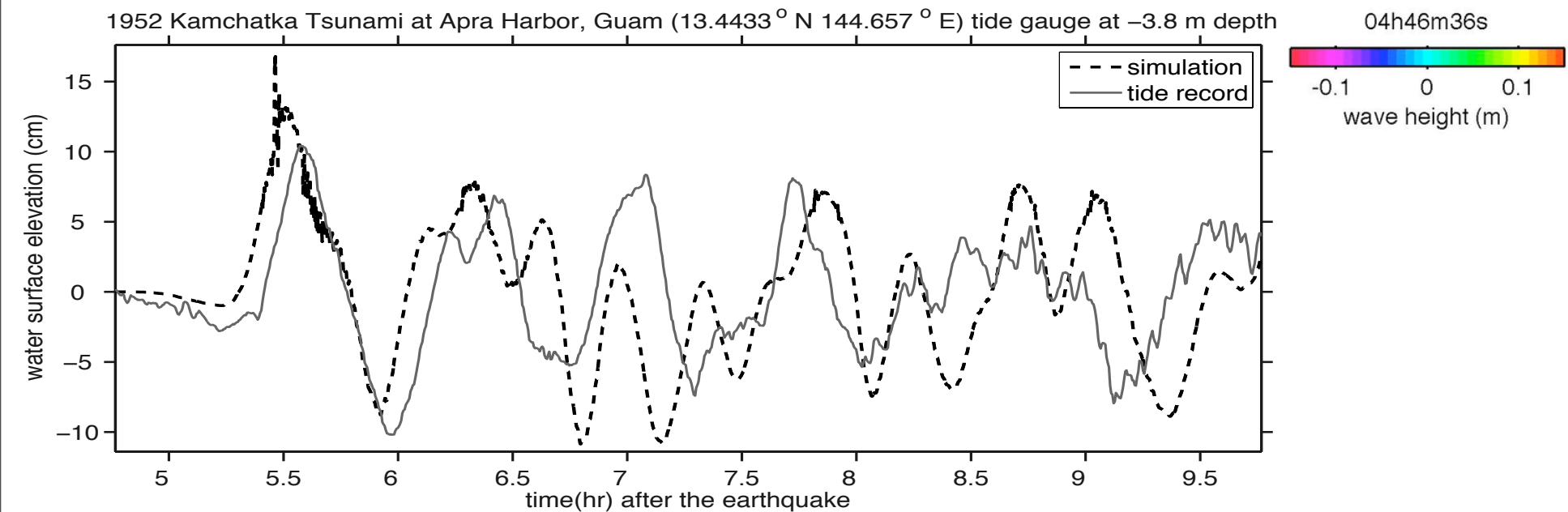
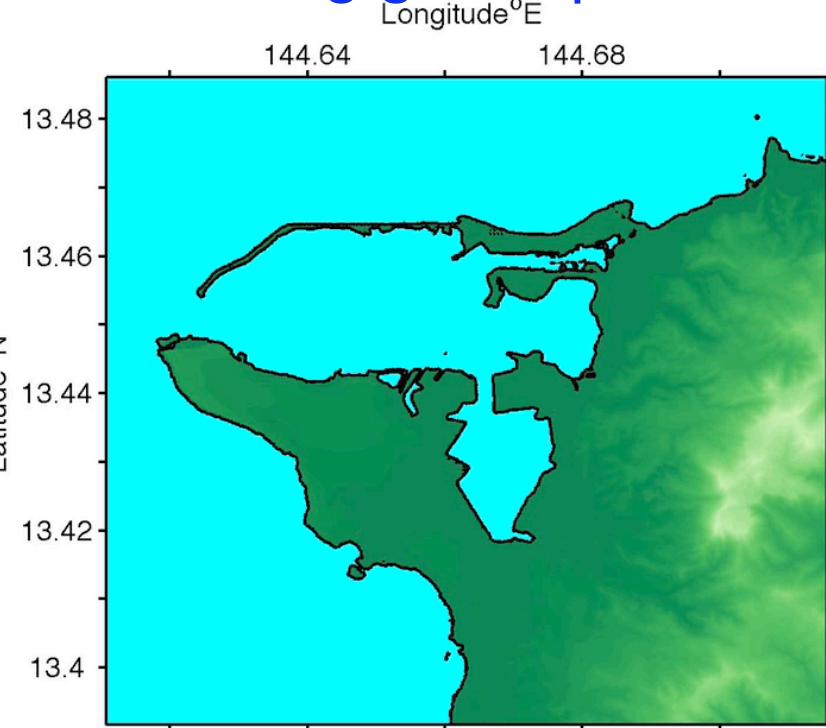
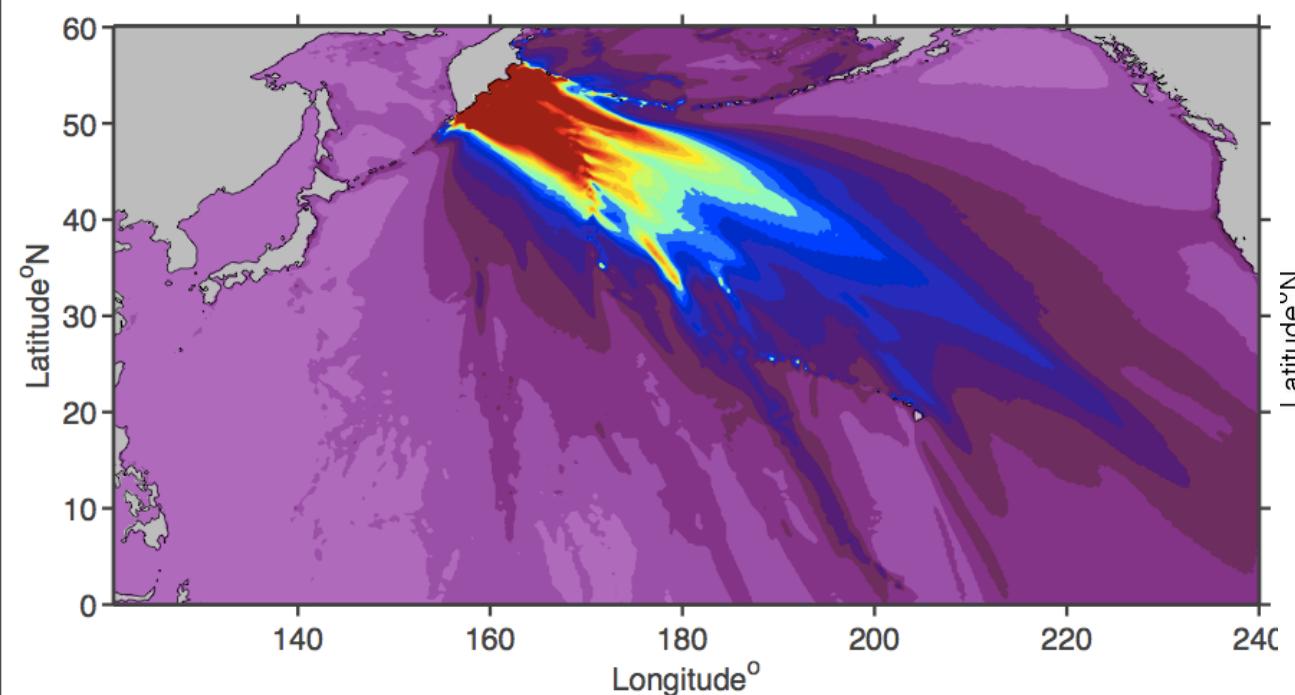
High Resolution Grids Developed for Ports and Harbors in Guam



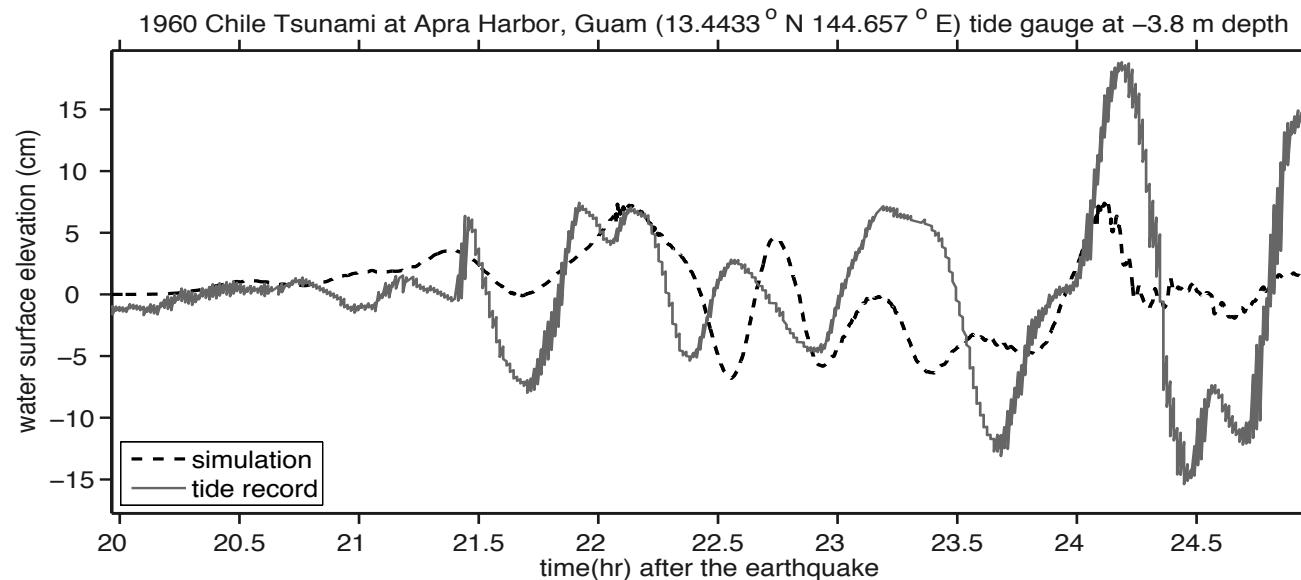
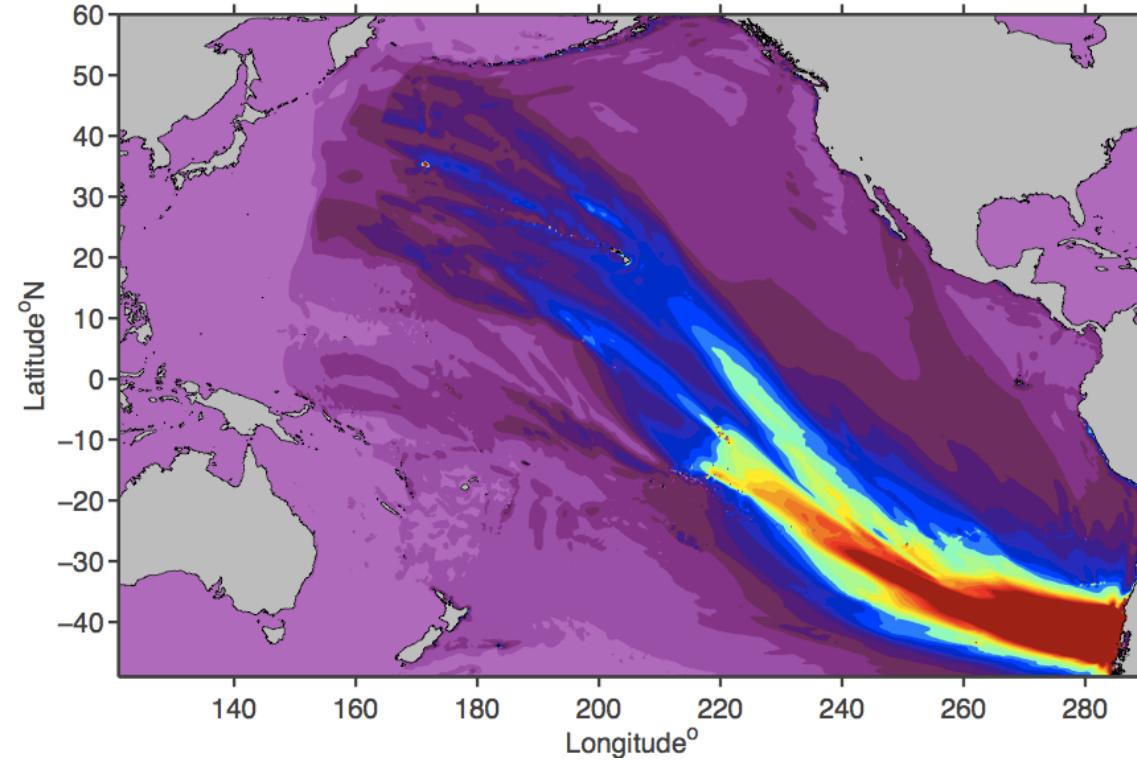
1952, 1960 and 1964 events at Apra Harbor, Guam (144.6567 E 13.4433 N).



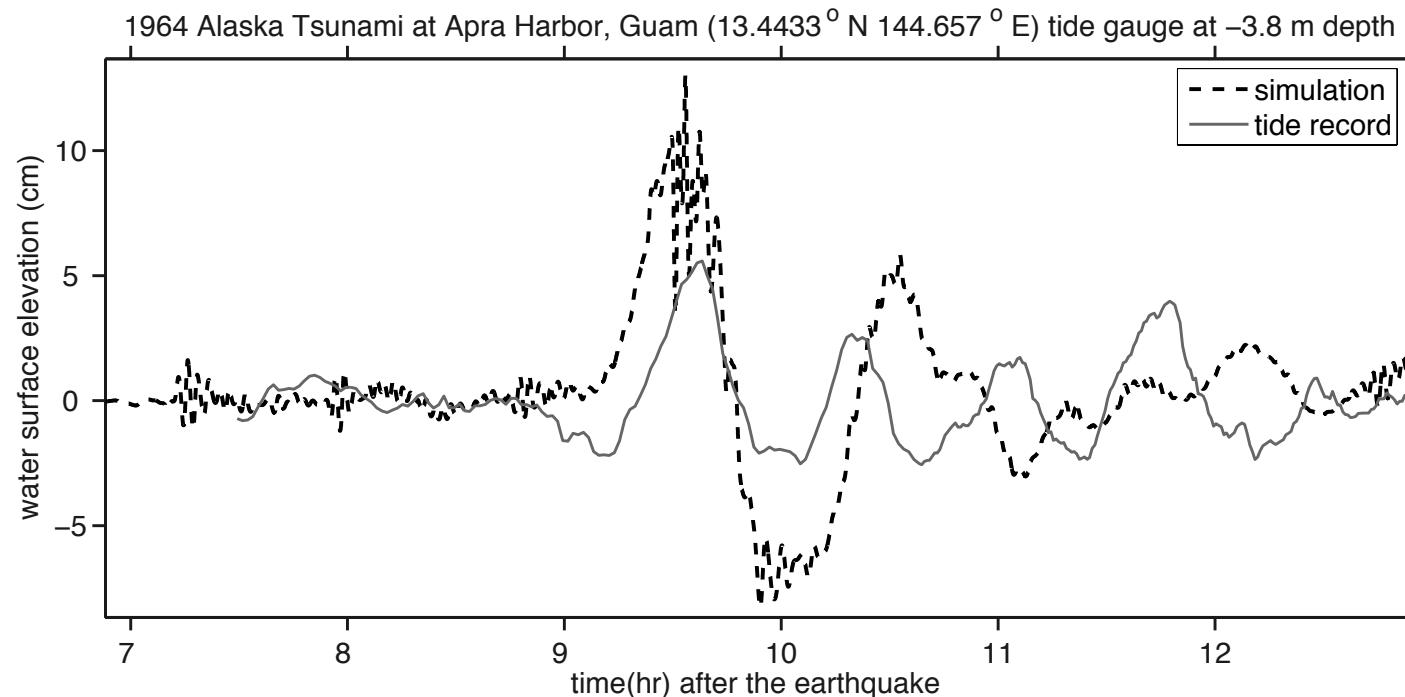
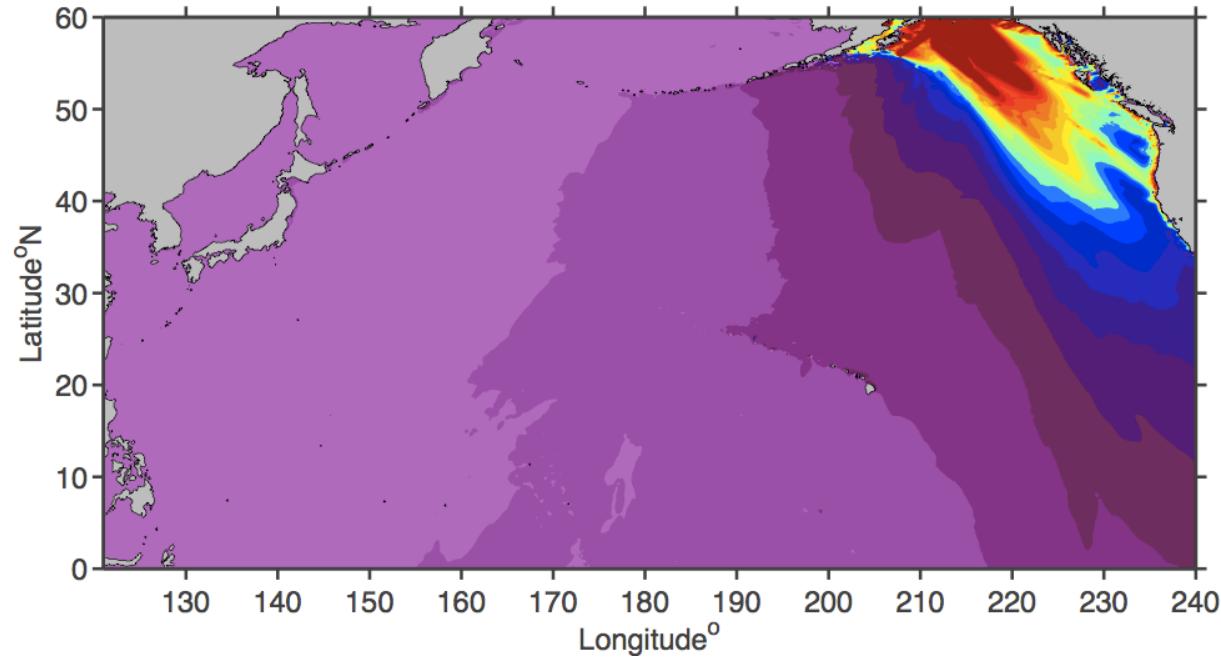
1952 Kamchatka Event simulation at Apra Harbor and tide gage comparison



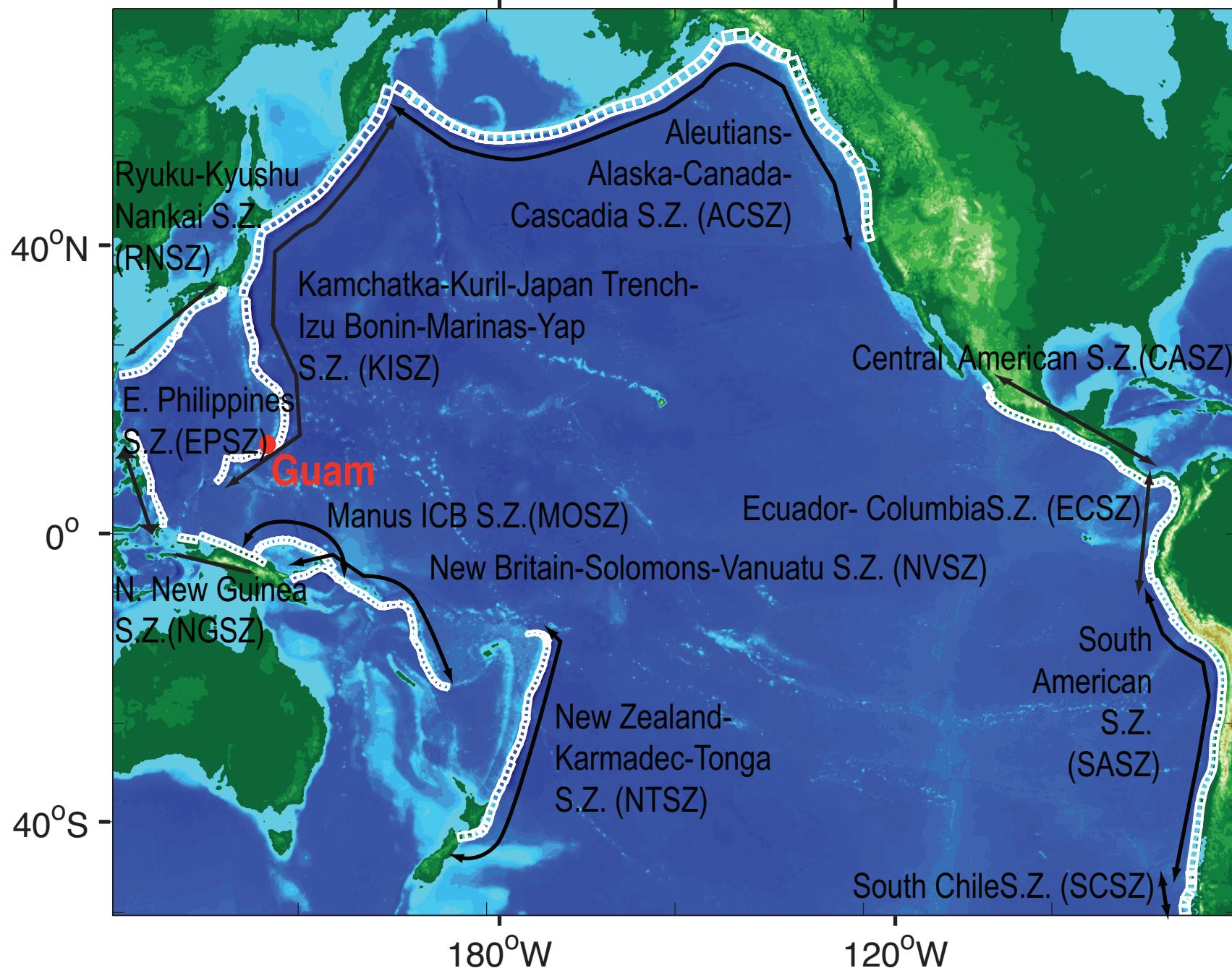
1960 Chile Event simulation at Apra Harbor and tide gage comparison



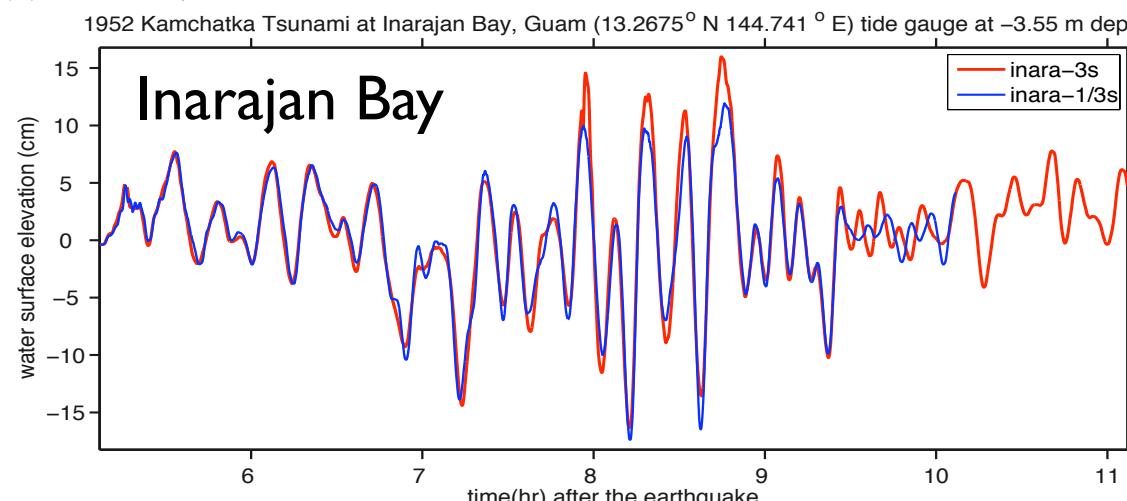
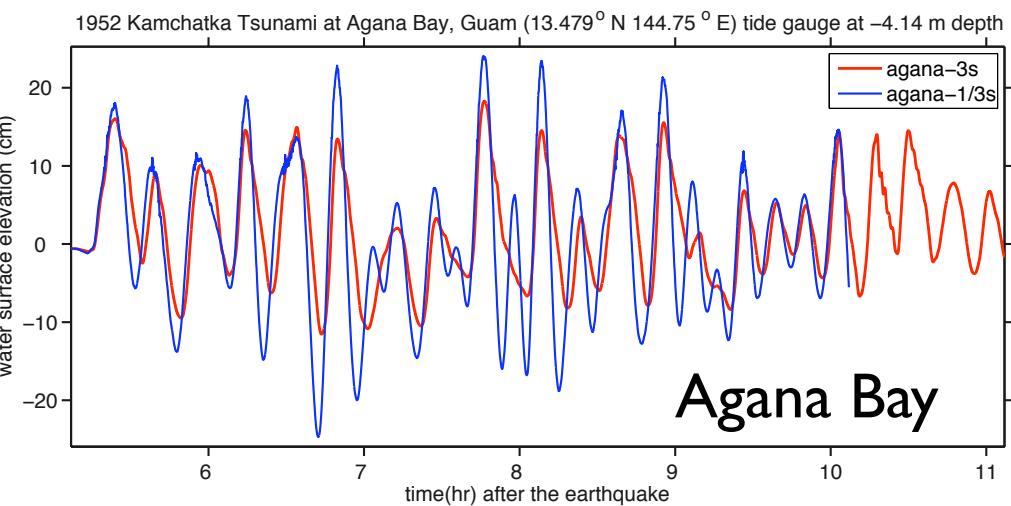
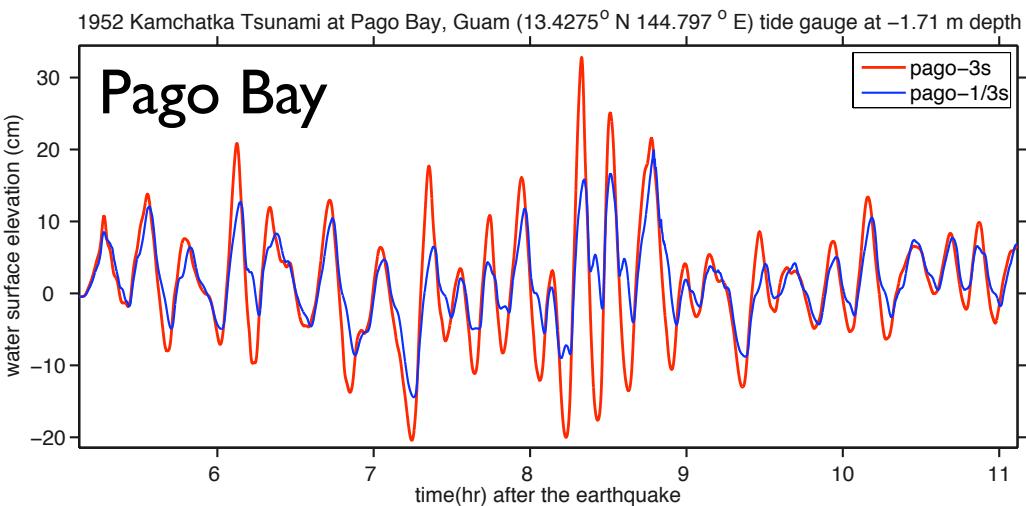
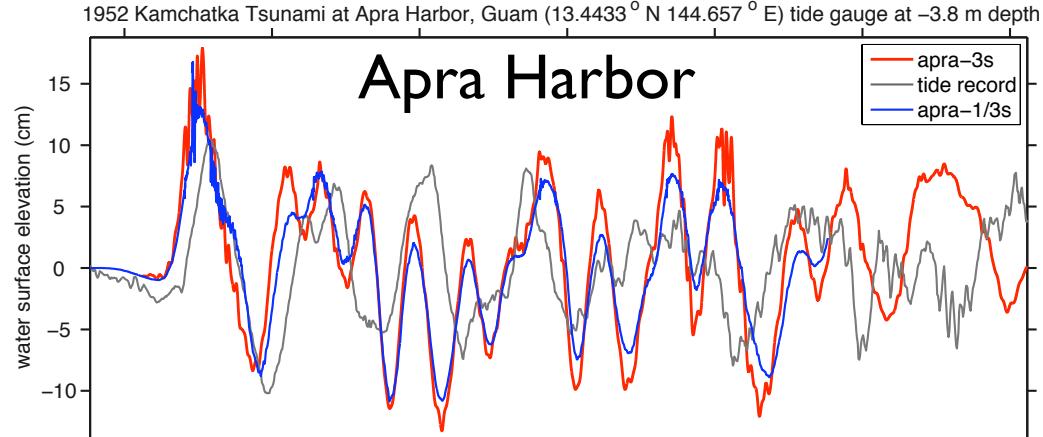
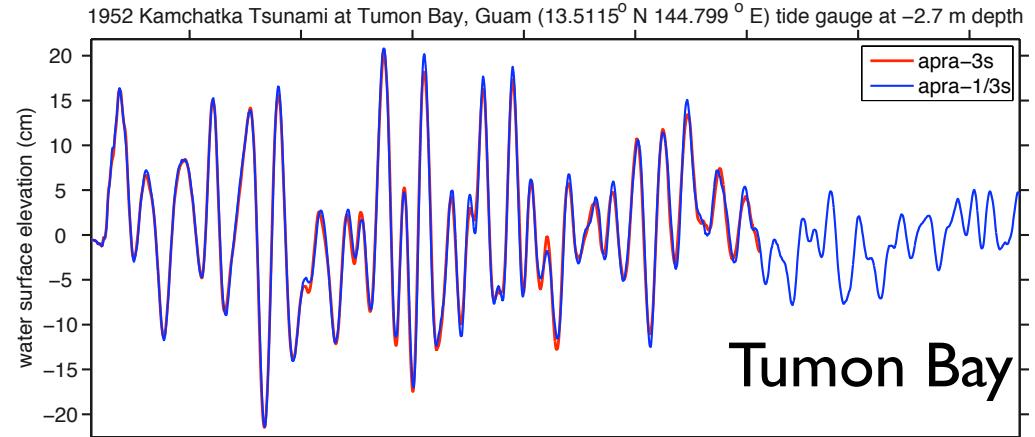
1964 Alaska Event simulation at Apra Harbor and tide gage comparison



Propagation Database



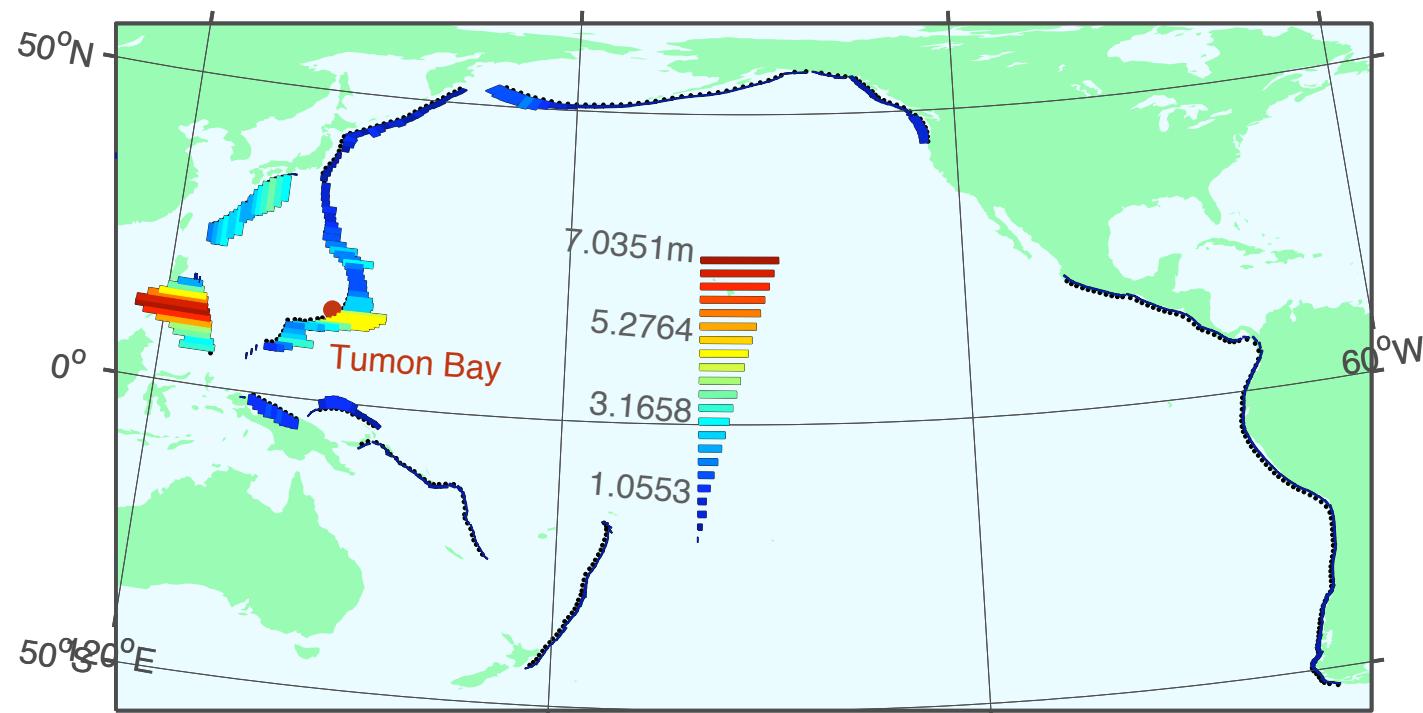
3-sec Fast Running Grids for Effective Source Region Study

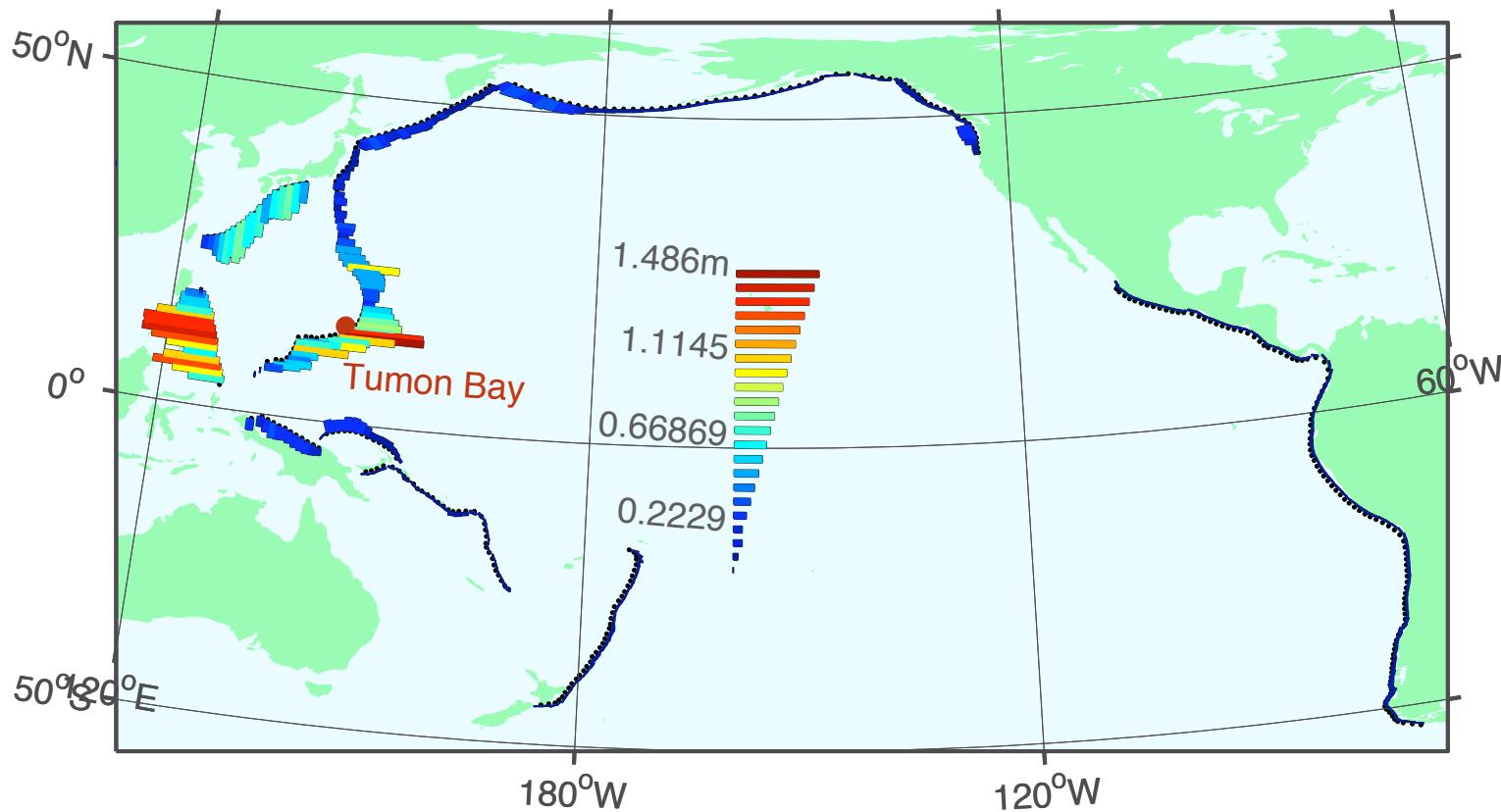


Kamchatka-Izu Bonin SZ, Ryuku-Kyushu Nankai SZ and East Philippines SZ have the highest wave response in Guam

Sub. Zones		Tumon (m)	Apra (m)	Pago (m)	Agana (m)	Inara (m)
	segs	segs	segs	segs	segs	segs
AASZ	05–11	1.6	05–11	1.4	02–08	2.7
AASZ	57–63	0.7	59–65	0.5	59–65	0.8
AASZ					55–61	0.5
AASZ					56–62	0.5
EPSZ	07–13	7.0	07–13	3.7	07–13	5.4
KSZ	16–22	1.0	20–26	0.8	20–26	1.1
KSZ	57–63	4.6	55–61	2.2	53–59	14.4
KSZ			56–62	2.2	57–63	14.5
MSZ	09–15	1.1	10–16	0.9	10–16	2.6
MSZ					09–15	0.8
MSZ					10–16	0.7
NGSZ	04–10	1.3	06–12	1.0	03–09	1.4
RNSZ	14–20	3.4	14–20	2.2	14–20	2.6
RNSZ					14–20	2.7
RNSZ					14–20	1.4

Table 3.3: Identified worst case scenarios for Guam from Pacific Rim subduction Zones with $M_w = 9.0$ earthquakes.

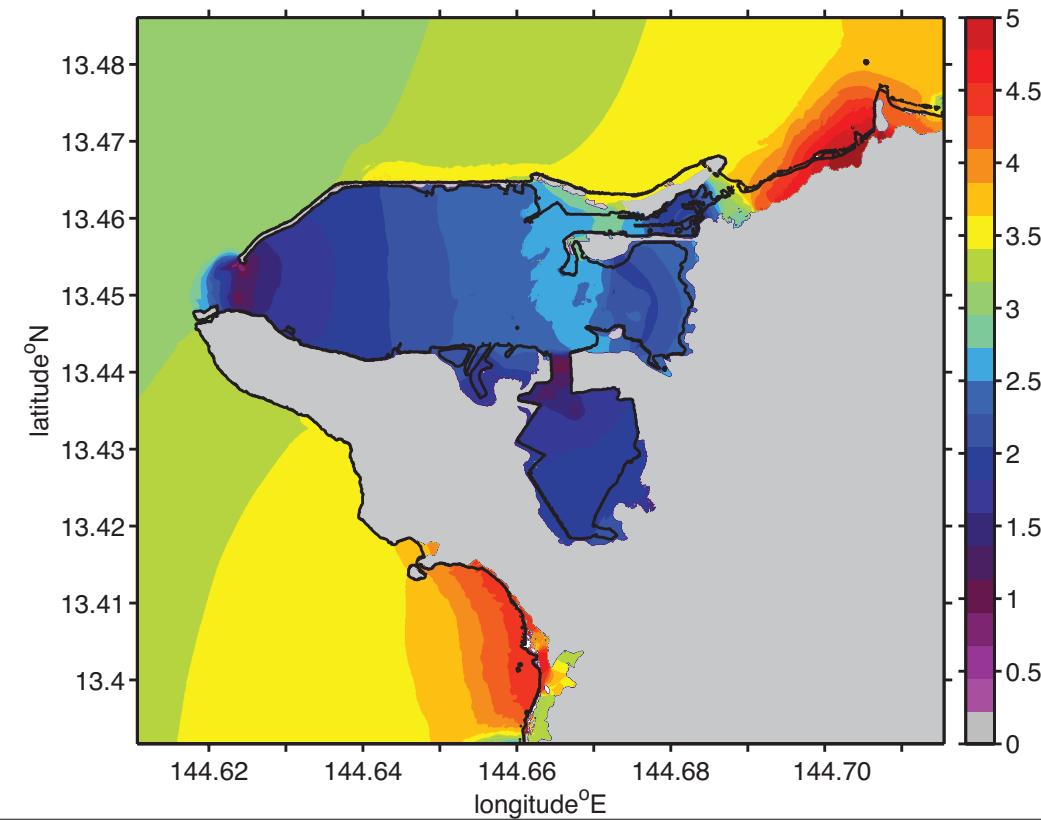
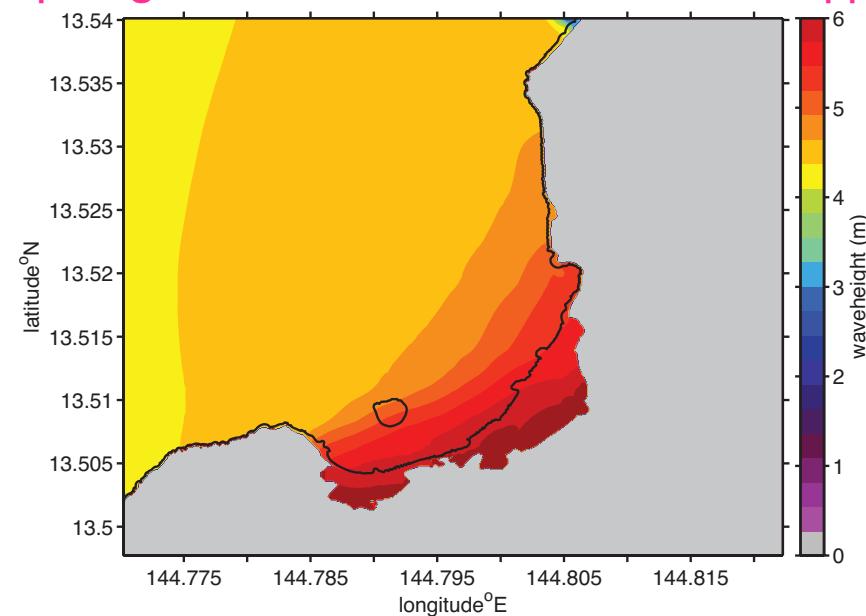
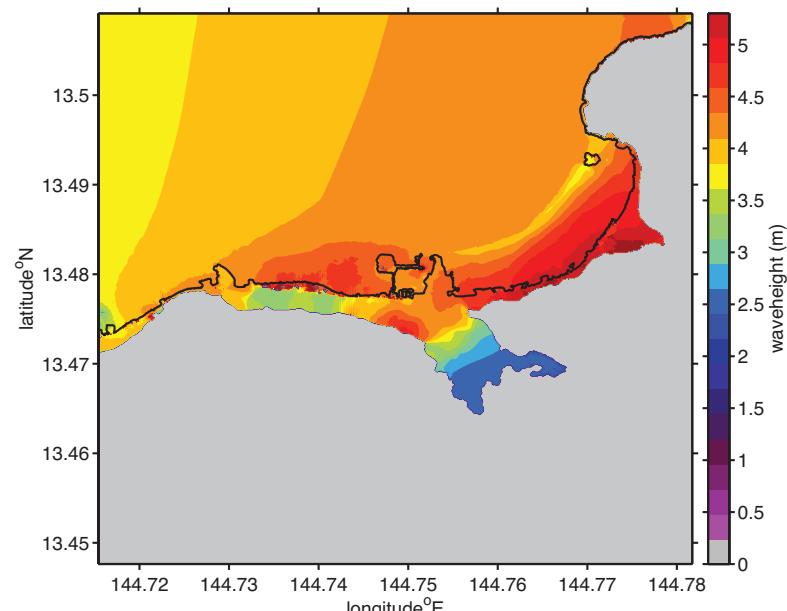




Sub. Zones	Tumon	Apra	Pago	Agana	Inara					
	(m)	(m)	(m)	(m)	(m)					
AASZ	06–09	0.3	06–09	0.31	03–06	0.59	05–08	0.26	03–06	0.41
AASZ	58–61	0.21	57–60	0.14	59–62	0.19	58–61	0.22	60–63	0.13
AASZ										
EPSZ	08–11	1.4	08–11	0.87	09–12	1.24	08–11	0.91	09–12	1.14
KSZ	20–23	0.27	20–23	0.26	20–23	0.35	20–23	0.25	20–23	0.27
KSZ	57–60	1.49	57–60	0.77	57–60	4.42	57–60	0.66	57–60	2.8
KSZ	66–70	1.02	66–69	0.59			66–69	0.79		
MSZ	10–13	0.25	10–13	0.25	10–13	0.84	10–13	0.25	10–13	0.47
NGSZ	09–12	0.28	03–06	0.24	02–05	0.33	09–12	0.25	04–07	0.32
RNSZ	07–10	0.78	17–20	0.65	08–11	0.5	18–21	0.54	05–08	0.36

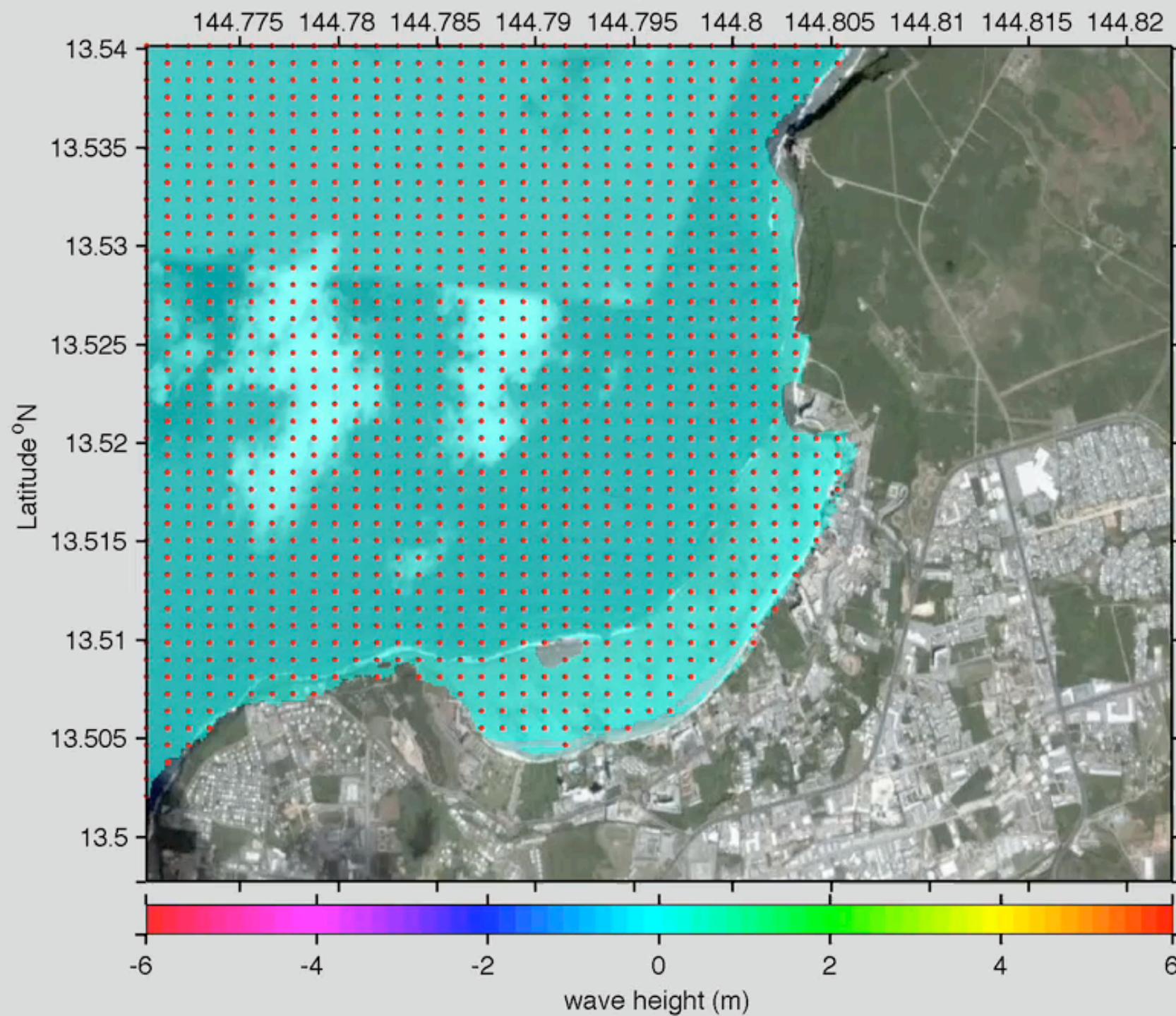
Table 3.2: Identified worst case scenarios for Guam from Pacific Rim subduction Zones with $M_w = 8.5$ earthquakes.

Maximum wave height, overland flow-depths and runup height from a Mw=9.0 event from Philippines

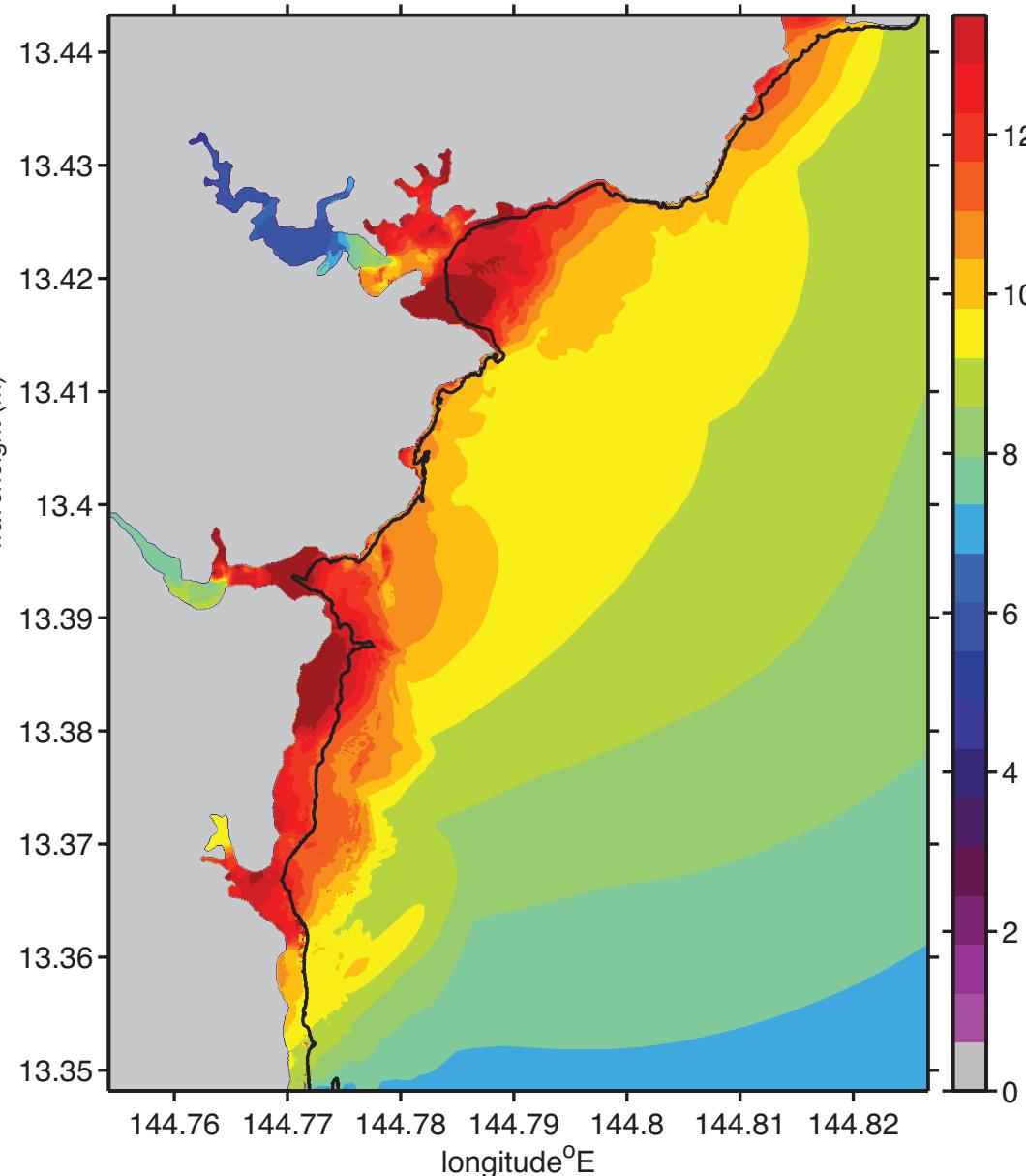
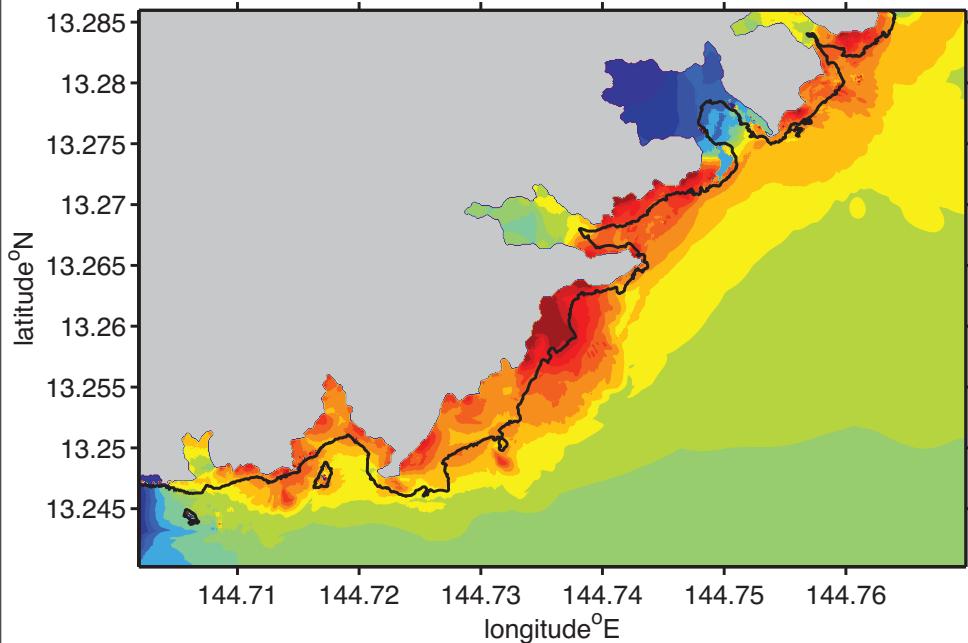


Time since EQ = 01h59m00s

Longitude $^{\circ}$ E



Maximum wave height, overland flow-depths and runup height from a Mw=9.0 event from Mariana Trench



Conclusion

- Tsunami hazard in Guam is highly dependent on location of the earthquake and an effective tsunami evacuation and warning system should consider the source region.
- We have limited historical records and 1960 Chile Tsunami has a significant wave height in Apra Harbor (20 cm), compared to 1964 (5 cm) and 1952 (10 cm).
- Optimized (SIMS) grids are used in computing the effective source regions (1128 runs) to identify worst case scenarios and finally 87 scenarios are used in hazard assessment with the latest LIDAR data is available.

Deliverables

- Paper and digital report.
- Tsunami inundation animations
- Maximum extent of inundation distances.
- Overland flow depth.
- Tsunami travel times to Guam.
- Maximum current speed within the harbors
- Maximum water levels within the harbors